



SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING
END OF SEMESTER II 2024/2025 EXAMINATION
PHY1201: PHYSICS 2

Date: 21st March 2025

Time: 16:00-19:00 Hours

Instruction:

1. This paper consists of **FIVE** questions.
2. Answer question 1 (Compulsory) and **ANY** other **TWO** questions
3. Show all your working in a systematic manner, where necessary, use diagrams to illustrate your concepts.

Important constants

Charge of an electron or proton, q_{e^-} or $q_{e^+} = 1.6 \times 10^{-19} C$

Mass of an electron $m_e = 9.1095 \times 10^{-31} kg$

Mass of a proton, $m_p = 1.673 \times 10^{-27} kg$

Mass of deuterons, $m_d = 2m_p$

Coulomb constant, $k_e = 8.99 \times 10^9 N \cdot m^2 / C^2$

Permittivity of free space constant $\epsilon_0 = 8.85 \times 10^{-12} C^2 / N \cdot m^2$

Permeability constant $\mu_0 = 1.26 \times 10^{-6} T \cdot m / A$

Magnetic permeability of iron $\mu_m = 5000\mu_0$

Gravitational acceleration $g = 9.8 m/s^2$

Dielectric strength of air, $E_{max,air} = 10^6 N/C$

$1eV = 1.6 \times 10^{-19} J$

QUESTION 1 (30 MARKS)

- (a) State the **Two** Kirchoff's rules (2 marks)
- (b) A spherical conductor has a radius of 30 cm. Calculate

- i. The maximum charge that can be placed on the sphere before dielectric breakdown of the surrounding air occurs (3 marks)
- ii. The maximum electric potential of the sphere (2 marks)
- (c) An iron toroid wound with 69 turns/m of wire carries a current of 5.00 A. Find the magnetic field B in the iron toroid (3 marks)
- (d) An electron is projected into a uniform electric field $\vec{E} = (1000\text{N/C})\hat{i}$ with an initial velocity of $\vec{v}_0 = (2.00 \times 10^6\text{m/s})\hat{i}$ in the direction of the field. How far does it travel before it is brought momentarily to rest? (3 marks)
- (e) A parallel-plate capacitor having a 14 cm square plates are separated by 2.0 mm is connected to a battery and charged to 12 V. Find
- i. The charge on the capacitor (3 marks)
- ii. Energy stored by the capacitor (3 marks)
- (f) During nuclear fusion, a uranium-235 nucleus captures a neutron to form an unstable uranium-236. The unstable nucleus then splits apart into two lighter nuclei as shown in Figure 1). In addition, two or three neutrons are released. Sometimes the two fission products are barium nucleus (charge 56e) and krypton nucleus (36e). Suppose that immediately after the split these nuclei are positive point charges separated by $r = 1.46 \times 10^{-15} \text{ m}$, calculate the potential energy of this two-charge systems in electron volts.

(4 marks)

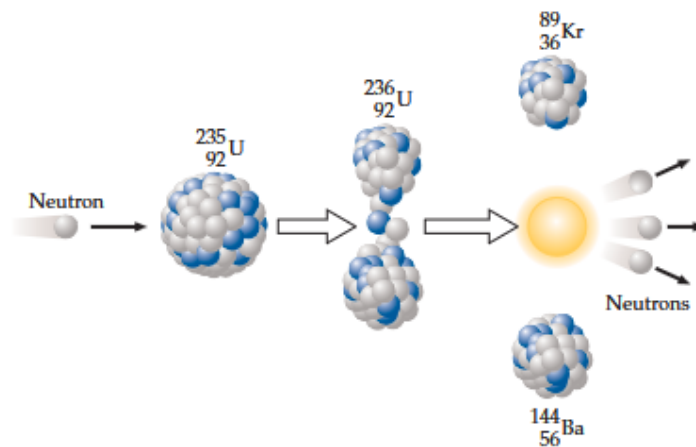


Figure 1

- (g) A cyclotron 53 m in radius is operated at an oscillator's frequency of 12 MHz.
- i. Find the magnitude of the magnetic field needed for the deuterons to be accelerated in the cyclotron (3 marks)

- ii. Calculate the resulting kinetic energy in MeV of deuterons (4 marks)

QUESTION 2 (15 Marks)

- (a) Three capacitors are connected as shown in Figure 2. The capacitors are initially uncharged, then connected to a 6.0V battery across point AB.

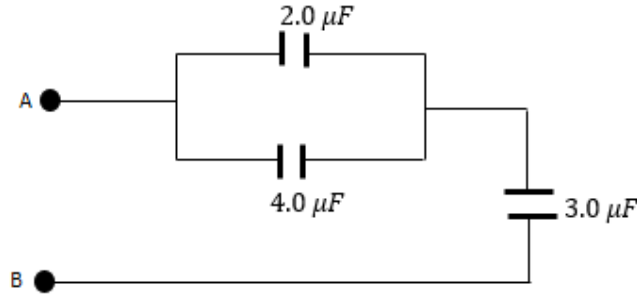


Figure 2

Find The potential difference across each capacitor (5 marks)

- (b) A spherical shell of radius $R = 3.00m$ has its centre at the origin and has a surface charge density of $\delta = 3.00 nC/m^2$. A point charge $q = 2.50 nC$ is at $(0,2.00) m$. Find the magnitude and direction of the electric field at a point P $(4.00, 0)m$ (10 marks)

QUESTION 3 (15 Marks)

- (a) An 11.0Ω resistor is connected across a battery with an electromotive force, \mathcal{E} of $6.00 V$ and internal resistance 1.00Ω . Determine
- Determine the terminal voltage of the battery (3 marks)
 - If the battery is rated at $150A.h$, calculate the energy stored by the battery (2 marks)
- (b) Two uncharged spherical conductors of radius $R_1 = 6.0 cm$ and $R_2 = 2.0 cm$, $6.0 cm$ apart are connected by a long, thin conducting wire of negligible charge as shown in Figure 3. A total charge of $Q = 80 nC$ is placed on one of the spheres and the system allowed to reach electrostatic equilibrium.



Figure 3

Calculate

- i. The charge on each sphere (4 marks)
- ii. The electric field strength at the surface of each sphere (3 marks)
- iii. The potential energy of the system in electron Volts (3 marks)

QUESTION 4 (15 Marks)

- (a) A square 12-turn coil has an edge length of 40.0 cm and carries a current of 3.00A flowing in anticlockwise direction when viewed from a point on the positive x-axis. Suppose it lies in the x-y plane as shown and it is perpendicular to a uniform magnetic field $\vec{B} = 0.300 T \hat{i} + 0.400T \hat{k}$ as shown in Figure 4.

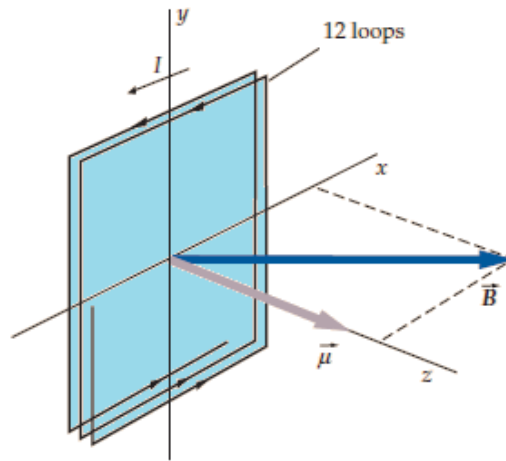


Figure 4

Find

- i. Magnetic moment of the coil (3 marks)
 - ii. The torque exerted on the coil (3 marks)
 - iii. The potential energy of the coil (3 marks)
- (b) Three light waves combine at a certain point where the electric components are,

$$E_1 = E_o \sin \omega t$$

$$E_2 = E_o \sin(\omega t + 60^\circ)$$

$$E_3 = E_o \sin(\omega t - 30^\circ)$$

Find the resultant component $E(t)$ at that point (6 marks)

QUESTION 5 (15 Marks)

- (a) Two tiny conducting balls of identical mass m and identical charge q hang from non-conducting threads of length L as shown in Figure 5. Suppose θ is so small such that $\tan \theta$ is approximately equal to $\sin \theta$.

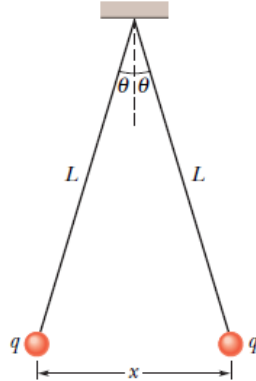


Figure 5

- i. Show that,

$$x = \left(\frac{q^2 L}{2\pi\epsilon_0 m g} \right)^{\frac{1}{3}}$$

(5 marks)

- ii. Suppose $L = 120 \text{ cm}$, $m = 10 \text{ g}$ and $x = 5.0 \text{ cm}$, determine the value of q .

(3marks)

- (b) Two long parallel wires 5.0 cm apart carry current $i_1 = 15 \text{ A}$ and $i_2 = 32 \text{ A}$ in opposite direction as shown in Figure 6. Determine the magnitude and direction of the net magnetic field at point P from the $+x$ -axis as shown on the figure. (7 marks)

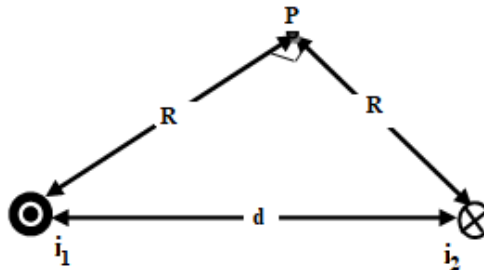


Figure 6